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EXPERIMENTAL EVALUATION OF Al6061 OF FLAT SECTION BY EXTRUSION PROCESS

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ABSTRACT

Metal forming process has become an important area in the industries due to their regular usage in all the relevant fields engineering. Extrusion makes an impact in the industries; a study of extrusion process with the variation of parameters h become difficult, as controlling of these parameters are very difficult. A research work was carried out for the Al60 specimen to check the various mechanical properties by varying the different parameters. In this work, the tensile properti and hardness were checked for both artificial ageing and natural ageing for the work pieces under different conditions a it is found that there is an increase in the tensile properties and hardness values, both in the case of natural ageing a artificial ageing.

KEYWORDS: Al6061, Natural ageing (NA), Ram speed & Artificial ageing (AA)

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Original Article

1. INTRODUCTION

A Metal forming is widely used in the current industry where the metal undergoes permanent deformation with change in the shape and size. Extrusion process is most important process which is defined as the raw billet is pushed through the die opening by ram to get the required shape of the product which may be circular, square etc. While extruding a metal, many parameters which affects the material behavior, the parameters which influences the extrusion process are Extrusion ratio, temperature, speed if these parameters are under well controlled, then it is possible to get the good extruded material. Many researchers have investigated in the field of extrusion process, it may be parametric study or in finding different properties [1-6].

A parametric study has been carried out to find out the effect of billet, extrusion ratio and geometry on the material flow [1]. Similar findings have been found by Hyperxtrude software in which the flow of material and its behavior in the two hole extrusion process on both hollow sections and thin walled sections were studied [2]. Extrusion was carried out for square section by using upper bond technique and it was found die length, pressure & at the boundary constant friction factor were investigated [3]. It was found that for Al6063, an experimental and numerical investigation was conducted to get the metal flow behavior and also its effects on quality of surface [4]. A Numerical simulation by DEFORM 2D was used to calculate the parameters which affects the extrusion process and also it has been investigated the optimum die angle which minimizes the surface permeation [5]. In this research work, numerical analysis was used to calculate the various metal flow conditions which affects the extrusion process [6]. HyperXtrude software was used to analyze the behavior of material and it was validated experimentally [7]. FEM was used to analyze the different parameters and also to get good quality welds in the longitudinal direction [8]. Material behavior and thermal behavior of high speed train were analyzed by using compressive test and thermo-mechanical test with DEFORM 3D simulation for the extrusion process [9]. With the

use of Functional data analysis, a mathematical model was developed to control the ram speed [10].

FE Analysis was carried out for porthole die extrusion process to get uniform metal flow and also found that friction at the die interface increases the temperature to greater extent [11]. A neural network algorithm was prepared for the process parameters which were well versed with the finite element analysis to get the desired output [12]. In the extrusion of Al7075, shapes with complex geometry where the thickness of walls were varied to achieve good quality product. A 3D simulation was used and different parameters were studied, which were validated with experimental results [13]. Microstructure analysis were carried out along with the Hardness and Tensile strength which were well versed in the desired range [28]. The parameters which influence the die geometries during transverse welding and the behavior of metal were studied [15]. Charge weld evolution has been systematically studied for different sections like hollow sections of both FEM analysis and experimental investigations met in good agreement [17]. Al 7005 was investigated for various temperature ranges and strain rate by using FEM simulation to analyse homogenized 7005 Al alloy [21].

From the above literature, it was observed that a limited work was carried out for the extrusion process with ageing and found out that the mechanical properties for the specimens were rare. In this paper, experimental investigations were conducted for Al6061 material for the flat cross section under different varying speed with natural ageing as well as for artificial ageing to find the mechanical properties such as hardness, tensile strength and predicted how the hardness varies with respect to the speed in different sections.

2. EXPERIMENTAL PROCEDURE

Figure 1 shows the sliced section of unprocessed billet and Figure 2 shows a billet prepared by casting process with the composition Si 0.75%, Fe 0.318%, Cu0.307%, Mg1.02%, Al97.3%, which passes into the extrusion machine having a capacity of 1650MT and maximum ram speed of 16mm/s to get the flat section, billet and die was preheated at 520^{o} & 450^{o} respectively before it was sent into the extrusion machine. In this Research work, the billet was sent into the extrusion machine by maintaining the ram speed of 1mm/s to obtain flat section, similarly by adjusting the ram speed of 2mm/s the second flat section extruded part was obtained and for 3mm/s ram speed obtained the third extruded part flat section. After the extruded parts were obtained, they were sent for ageing for about 8 hours by maintaining the temperature at about 165^{0}. In this research work, investigation of both ageing and non ageing specimens was carried out. In this, mechanical properties were studied. Initially, hardness tests were conducted on Brinnel Hardness testing machine by applying a load of 62.5kg, Tensile specimens were prepared in the milling machine and it was tested under UTM for various results such as ultimate strength, % of elongation, Stress-Strain curves were studied in detail for all the specimens.

Figure 1: Shows the Al6061 Specimen Before Extrusion.

Figure 1 Shows the specimen sample before extrusion it was sliced from the billet and hardness value for the same was noted with Brinell Hardness number and it was found to be 42.2BHN.

Figure 2: Shows the Billet used for Extrusion

3. EXPERIMENTAL RESULTS

Figure ure1 shows Al6061 sliced section of billet before extrusion process and billet in the Figure 2 which proceeds in the extrusion machine. For extrusion, the flat die was used to get flat section when it comes out of the die opening from the extrusion machine.

3.1 Hardness Results

Hardness tests were conducted for extruded natural ageing flat specimens and also for artificial ageing flat specimens, it was found that an increase in the hardness values was observed for the extrusion process. As the parameter-ram speed varies for 1,2,3mm/s the hardness values in BHN for NA were 60.1,73 & 76 respectively and for the ram speed 1,2,3mm/s the hardness values 95,99,102 for artificial ageing respectively. It was observed from the results that the hardness values were found to have significant increase for artificial ageing specimens when compared with NA because of the grain size, the hardness depends on the grain size, it was also observed that the ageing was done perfectly to obtain the uniform hardness values throughout the sections for both NA and AA the hardness of AZ91 alloy was observed for [28].

3.2 Tensile Test Results

Figure 3 shows the extruded ageing specimens (8 hours of heating at 165^{o} in an oven) and Figure 4 shows the extruded natural ageing specimen, Figure 5 & 6 shows tensile specimens of AA and NA respectively the tensile test results such as Ultimate tensile strength (UTS), Percentage of Elongation for the variation of ram speed specimens for 1, 2, 3mm/s for both NA and AA were obtained as shown in Table 1.

The Ultimate strength for NA specimens with ram speed of 1mm/s, 2mm/s and 3mm/s were 29.15, 32.80 and 33.81MPa respectively it was observed that the ultimate tensile strength was maximum with ram speed of 3mm/s. Percentage of elongation for ram speeds 1mm/s, 2mm/s and 3mm/s were 23.68,23.08 and 22.88 respectively, it was found that the percentage of elongation is decreasing as the speed increases.

Similarly for artificial ageing, the ultimate strength for ram speed of 1mm/s, 2mm/s and 3mm/s were 37.41, 38.78 and 38.90kgf/mm^2 respectively, in this case also, ultimate tensile strength for 3mm/s was maximum, the percentage of elongation for ram speed of 1mm/s,2mm/s and 3mm/s were 18.04, 17.68 and 17.21 respectively, it was observed that the percentage of elongation for 3mm/s was minimum when comparing with 1mm/s and 2mm/s ram speed.

In comparison with NA and AA, the UTS for AA was significantly higher and % of elongation was minimum in all the specimens. Figure 7 shows the broken tensile test specimen under Universal Testing Machine. From the above observation, relatively higher values of strength can be obtained in the case of artificial ageing specimens when compared with Natural ageing specimens. Similar findings were seen in [28].

Graph shows the results for stress-strain diagram for all the specimens which has been tested for NA and AA with the ram speed variation of 1mm/s, 2mm/s, 3mm/s, for natural ageing specimens the stress value for ram speed of 1mm/s was 29, 2mm/s was 33 and 3mm/s was 34kgf/mm^2 respectively maximum stress was observed for ram speed of 3mm/s when comparing with ram speeds of 1mm/s and 2mm/s, for artificial ageing the stress values for 1mm/s was 39, 2mm/s was 39.5, 3mm/s was 39.6kgf/mm^2 the stress was maximum for the specimen with ram speed of 3mm/s but for this case i.e. artificial ageing there were not much significant increase in the stress values for 1mm/s ram speed and 2mm/s ram speed and similarly when comparing with NA and AA specimens for AA, the stress values are maximum when comparing with natural ageing specimens for all the specimens.

It was also observed from the graph that strain values for the ram speeds of 1mm/s, 2mm/s and 3mm/s for natural ageing was decreasing and for artificial ageing it was observed to be maximum for 2mm/s speed.

Table 1: Tensile properties of Natural Ageing and Artificial Ageing Flat Specimens

Sample	Ram Speed (in mm/s)	Ultimate Tensile Stength (In MPa)	% of Elongation
Flat NA	1	29.15	23.68
Flat NA	2	32.80	23.08
Flat NA	3	33.81	22.88
Flat AA	1	37.41	18.04
Flat AA	2	38.78	17.68
Flat AA	3	38.90	17.21

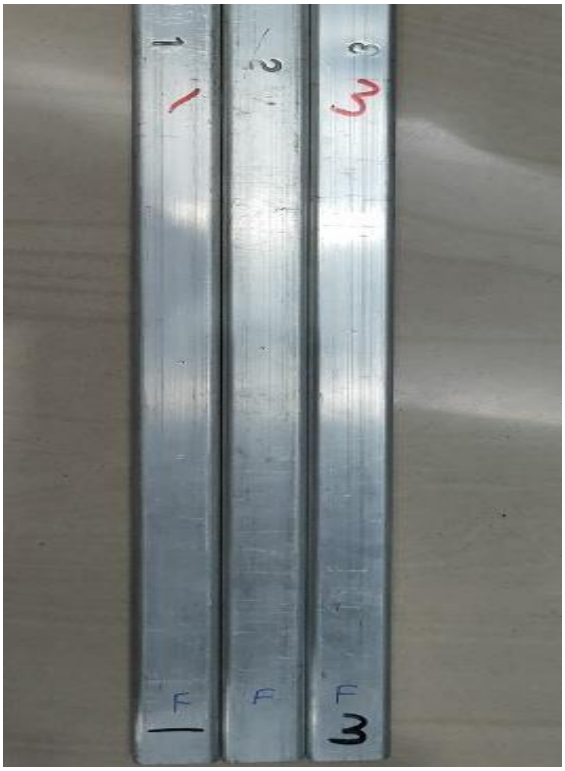

Figure 3: Extrudes Flat Specimens Natural Ageing

Figure 4: Extrudes Flat Specimens Artificial Ageing

Figure 5: Tensile Specimens Artificial Ageing

Figure 6: Tensile Specimens Natural Ageing

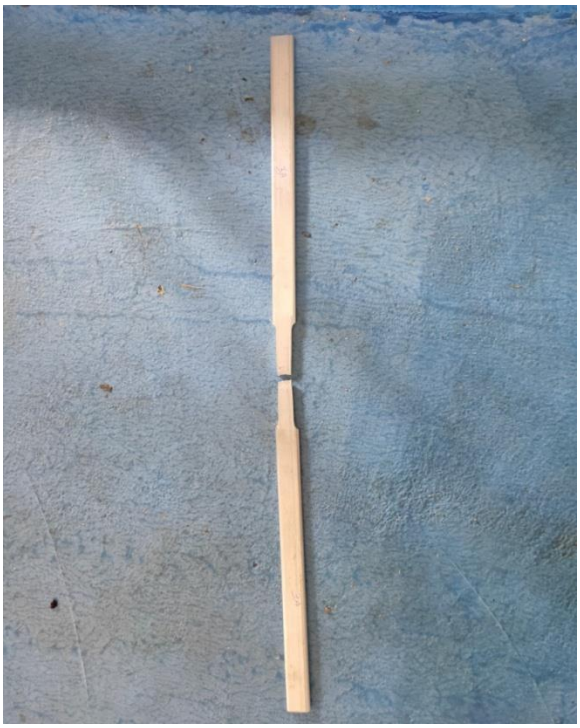

Figure 7: Broken Piece of Flat Section

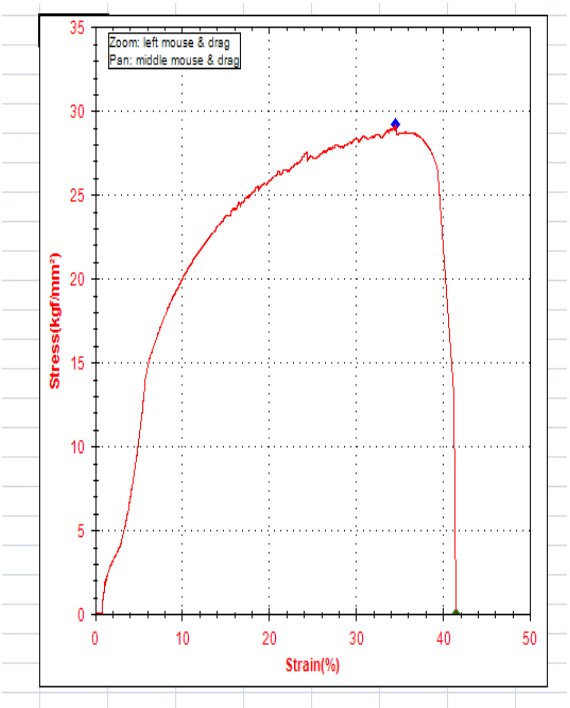

Figure 8: Stress vs Strain of NA with 1mm/s Speed

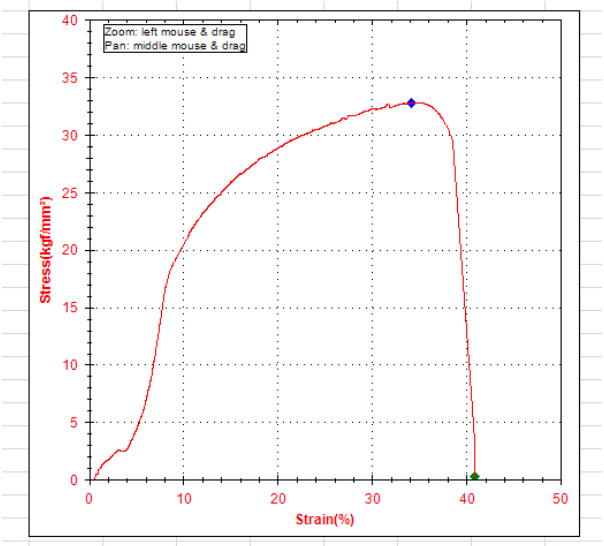

Figure 9: Stress vs Strain of NA with 2mm/s Speed

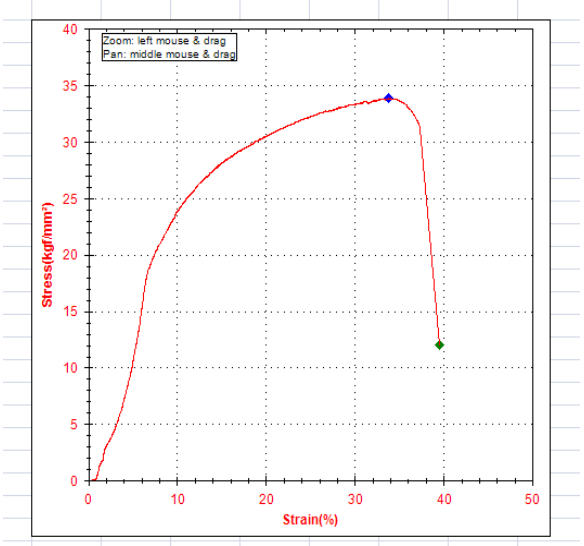

Figure 10: Stress vs Strain of NA with 2mm/s Speed

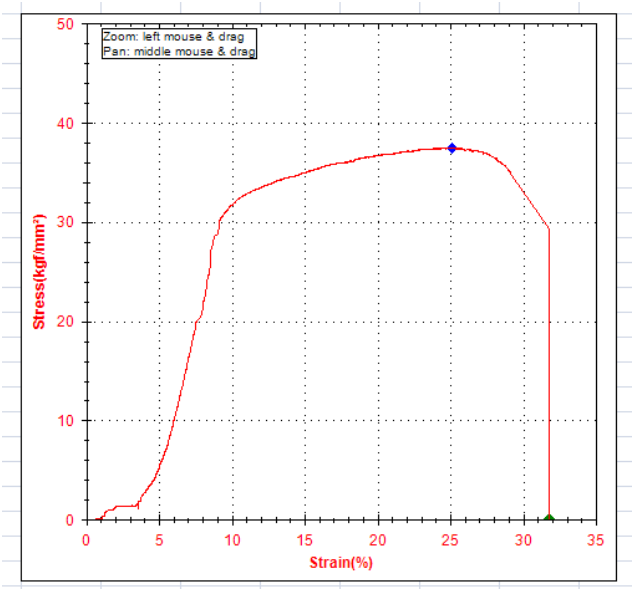

Figure 11: Stress Vs Strain of 1mm/s speed for Ageing

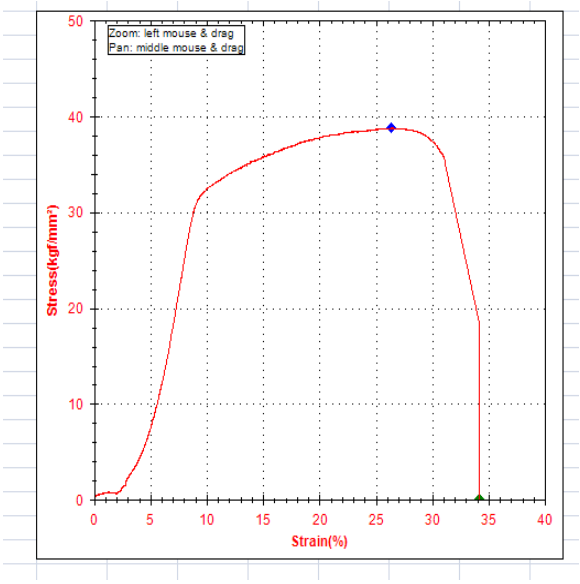

Figure 12: Stress Vs Strain of 2mm/s Speed for Ageing

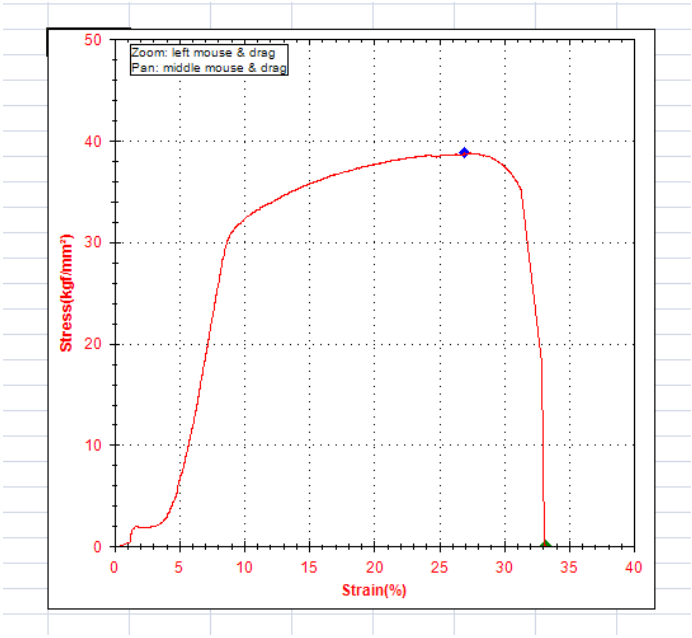

Figure 13: Stress Vs Strain of 3mm/s Speed for Ageing

4. CONCLUSIONS

- Al6061 material was extruded for natural ageing and artificial ageing under different ram speed and mechanical properties were investigated for flat section. The results are observed as follows.
- Hardness values for the specimen with ram speed 3mm/s was highest when compared with 2mm/s and 1mm/s. in the case of natural ageing.
- In the case of artificial ageing, the hardness values for the ram speed with 3mm/s is greater when compared with 2mm/s and 1mm/s.
- As the ram speed increases, the hardness values increases in both AA and NA of extruded Al6061 alloy.

- Extruded Al6061 alloy with the artificial ageing have better hardness values when compared to extruded Al6061 alloy with natural ageing.
- Ultimate tensile strength values for Al6061 extruded flat section with NA for ram speed of 3mm/s was greater than ram speed of 2mm/s and 1mm/s.
- For Extruded Al6061 with AA with ram speed, 3mm/s was greater when compared with the ram speeds of 2mm/s & 1mm/s.
- For Extruded Al6061 with AA UTS, values were greater than when compared with NA extruded Al6061.
- Percentage of Elongation for AA & NA was found to be decreased when ram speed increased.
- Stress-Strain curves for different specimens were observed. It was found that AA results were maximum when comparing with NA and for ram speed with 3mm/s shows maximum stress in both NA and AA. Strain values were also observed and it was decreasing as the speed increased in the case of natural ageing and for artificial ageing, strain value is maximum for 2mm/s ram speed.

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